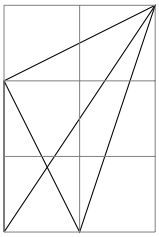
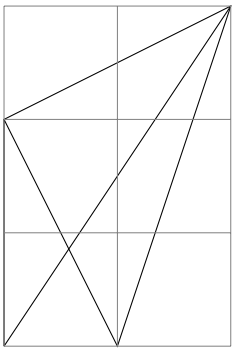
1 SIMPLE STRAIGHT LINES

```
\begin{tikzpicture}
        \draw (0,0) -- (1,2);
\end{tikzpicture}
```

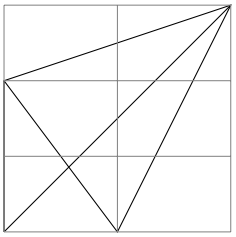


```
\begin{tikzpicture}
        \draw (0,0) -- (0,2) -- (2,3) -- (1,0) -- (0, 2);
        \draw (0,0) -- (2,3);
        \draw[help lines] (0, 0) grid (2, 3);
\end{tikzpicture}
```

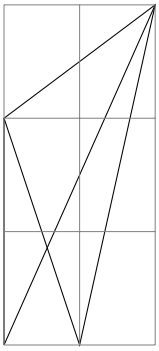
2 SCALING PICTURES



```
\begin{tikzpicture}[scale = 1.5]
        \draw (0,0) -- (0,2) -- (2,3) -- (1,0) -- (0, 2);
        \draw (0,0) -- (2,3);
        \draw[help lines] (0, 0) grid (2, 3);
\end{tikzpicture}
```

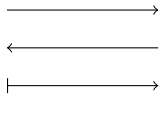


```
\begin{tikzpicture}[xscale = 1.5]
        \draw (0,0) -- (0,2) -- (2,3) -- (1,0) -- (0, 2);
        \draw (0,0) -- (2,3);
        \draw[help lines] (0, 0) grid (2, 3);
\end{tikzpicture}
```

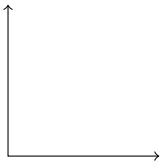


```
\begin{tikzpicture}[yscale = 1.5]
        \draw (0,0) -- (0,2) -- (2,3) -- (1,0) -- (0, 2);
        \draw (0,0) -- (2,3);
        \draw[help lines] (0, 0) grid (2, 3);
\end{tikzpicture}
```

3 ARROWS

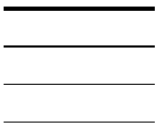


```
\begin{tikzpicture}
\draw [->] (0,0) -- (2, 0);
\draw [<-] (0, -0.5) -- (2,-0.5);
\draw [|->] (0,-1) -- (2,-1);
\end{tikzpicture}
```



```
\begin{tikzpicture}
\draw [<->] (2, 0) -- (0,0) -- (0,2);
\end{tikzpicture}
```

4 CHANGING THICKNESS



```
\begin{tikzpicture}
\draw [ultra thick] (0,1) -- (2, 1);
\draw [thick] (0,0.5) -- (2,0.5);
\draw [thin] (0,0) -- (2,0);
\draw [ultra thin] (0, -0.5) -- (2, -0.5);
\end{tikzpicture}
```

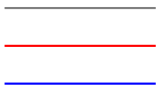
Full options include ultra thin, very thin, thin, semithick, thick, very thick, and ultra. Custom widths can also be used.

```
\begin{tikzpicture}
\draw [line width = 12] (0, 0) -- (2,2);
\draw [line width = 0.2 cm] (4, 0.75) -- (5, 0.25);
\end{tikzpicture}
```

5 DASHES AND DOTS

```
\begin{tikzpicture}
\draw [dashed, ultra thick] (0,1) -- (2,1);
\draw [dashed] (0,0.5) -- (2,0.5);
\draw [dotted] (0,0) -- (2,0);
\end{tikzpicture}
```

6 COLORS



```
\begin{tikzpicture}
\draw [gray, thick] (0,1) -- (2, 1);
\draw [red, thick] (0,0.5) -- (2, 0.5);
\draw [blue, thick] (0,0) -- (2, 0);
\end{tikzpicture}
```

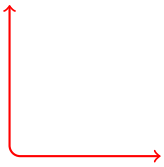
Other colors include red green yellow blue cyan magenta black gray darkgray lightgray brown lime olive orange pink purple teal violet white

```
\tikz{\draw [<color>, line width = 6] (0,0) -- (0.5, 0);}
```

7 CURVES

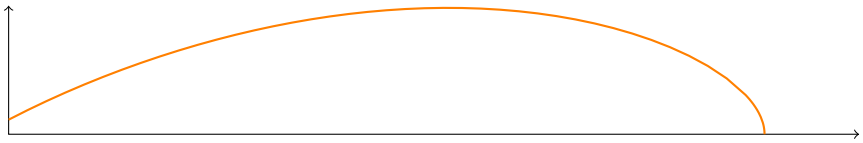
```
\begin{tikzpicture}
\draw [blue] (0,0) rectangle (2,1);
\draw [red, ultra thick] (3, 0.5) circle [radius = 0.5];
\draw [green, thick] (5.5,0.25) arc [radius = 1, start angle = 45,
    end angle = 135];
\end{tikzpicture}
```

Arc of radius 1 starts at the point (6,0), leaves it at an angle of 45 degrees and stops when its slope is 135 degrees. To make paths take smoother turns,



```
\begin{tikzpicture}
\draw [<->, rounded corners, thick, red]
        (0,2) -- (0,0) -- (2,0);
\end{tikzpicture}
```

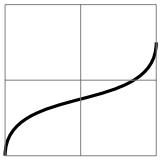
Lots of anchor points can be specified explicitly to make a smoother curve.



```
\begin{tikzpicture}[xscale=25,yscale=5]
\draw [<->] (0.6,1.34) -- (0.6,1) -- (1.05,1);
\draw[orange, thick] (0.6, 1.0385) --
(0.61, 1.06372) -- (0.62, 1.08756) -- (0.63, 1.11012) --
(0.64,1.13147) -- (0.65, 1.15166) -- (0.66, 1.17074) --
(0.67, 1.18874) -- (0.68,1.20568) -- (0.69, 1.22157) --
%[... lots of points ...]
(0.9991, 1.03042) -- (0.9992, 1.02866) -- (0.9993,1.02679) --
(0.9994, 1.02478) -- (0.9995, 1.0226) -- (0.9996, 1.02019) --
(0.9997,1.01747) -- (0.9998, 1.01424) -- (0.9999, 1.01005) --
```

```
(0.9999,1.01005) -- (0.99991, 1.00953) -- (0.99992, 1.00898) --
(0.99993,1.0084) -- (0.99994, 1.00778) -- (0.99995, 1.0071) --
(0.99996,1.00634) -- (0.99997, 1.00549) -- (0.99998, 1.00448) --
(0.99999, 1.00317) -- (1,1) ;
\end{tikzpicture}
```

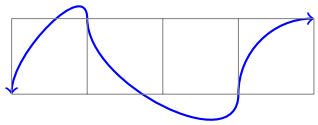
A simpler way to draw a curve is to specify the inlet and exit points, and the inlet and exit angles.



```
\begin{tikzpicture}
\draw[very thick] (0,0) to [out=90,in=195] (2,1.5);
\draw[help lines] (0,0) grid (2,2);
\end{tikzpicture}
```

To decipher the angles,

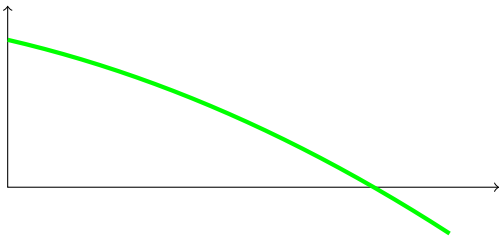
- Draw a vector at the beginning, (0,0) pointing *right* along the base of the figure. Rotate the vector *counterclockwise* until it is tangent with the drawn curve. The angle turned is the `out` angle.
- Draw a vector at the end, (2, 1.5) pointing to the *left* parallel to the base of the figure. Rotate the vector *counterclockwise* until it is tangent with the drawn curve. The angle turned is the `in` angle.



```
\begin{tikzpicture}
\draw [<->, thick, blue] (0,0) to [out = 90, in = 90] (1,1) [out =
    -90, in = -90] to (3,0) to [out = 90, in = 180] (4,1);
\draw [help lines] (0,0) grid (4,1);
\end{tikzpicture}
```

8 PLOTTING FUNCTIONS

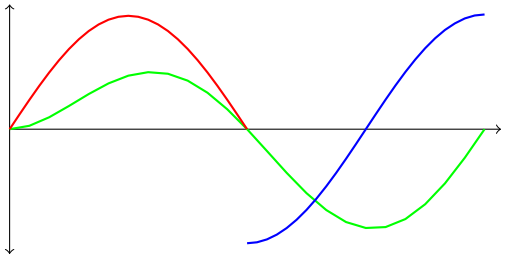
Ti*k*z has a math engine to plot functions.



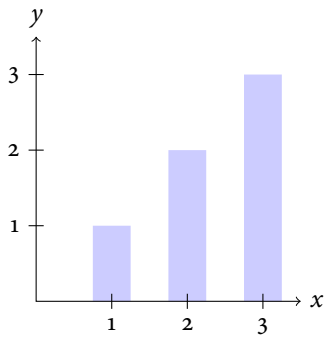
```
\begin{tikzpicture}[xscale = 13, yscale = 3]
\draw [<->] (0, 0.8) -- (0,0) -- (0.5, 0);
\draw [green, ultra thick, domain = 0:0.45]
plot (\x, {0.65 - \x - 2*\x*\x});
\end{tikzpicture}
```

Available functions include `factorial(\x)`, `sqrt(\x)`, `pow(\x,y)` (x^y), `exp(\x)`, `ln(\x)`, `log10(\x)`, `log2(\x)`, `abs(\x)`, `mod(\x,y)`, `round(\x)`, `floor(\x)`, `ceil(\x)`, `sin(\x)`, (`sin(\x r)` for radians), `cos(\x)`, `cos(\x r)`, `tan(\x)`, `tan(\x r)`, `min(\x, y)`, `max(\x, y)`.

These functions can be mixed together, along with two provided constants, `e` = 2.718281828, and `pi` = 3.141592654.



```
\begin{tikzpicture}[yscale=1.5]
\draw [->] (0,0) -- (6.5,0);
\draw [<->] (0,-1.1) -- (0,1.1);
\draw [green,domain=0:2*pi] plot (\x, {(sin(\x r)* ln(\x+1))/2});
\draw [red,domain=0:pi] plot (\x, {sin(\x r)});
\draw [blue, domain=pi:2*pi]
plot (\x, {cos(\x r)*exp(\x/exp(2*pi))});
\end{tikzpicture}
```



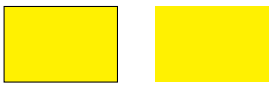

```
\begin{tikzpicture}
\draw [ycomb, color = blue!20, line width = 0.5 cm]
        plot coordinates{(1,1) (2,2) (3,3)};
\draw (1, -0.1) node [below] {1} -- (1, 0.1)
        (2, -0.1) node [below] {2} -- (2, 0.1)
        (3, -0.1) node [below] {3} -- (3, 0.1);
\foreach \i in {1,2,3}
\draw  (-0.1, \i) node [left] {\i} -- (0.1, \i);
\draw [<->] (0,3.5) node [above] {$y$}
                        -- (0,0)
                        -- (3.5,0) node [right] {$x$} ;
\end{tikzpicture}
```

9 FILLING AREAS

Closed paths can be filled.

```
\begin{tikzpicture}
\draw [fill = red, ultra thick] (0,0) rectangle (1,1);
\draw [fill = red, ultra thick, red] (2,0) rectangle (3,1);
\draw [blue, fill = blue] (4,0) -- (5,1) -- (4.75, 0.15) -- (4,0);
\draw [fill] (7, 0.5) circle [radius = 0.1];
\draw [fill = orange] (9,0) rectangle (11,1);
\draw [fill = white] (9.25, 0.25) rectangle (10, 1.5);
\end{tikzpicture}
```

To suppress the outline, replace the `\draw` command with the `\path` command.

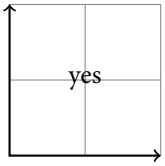


```
\begin{tikzpicture}
\draw [fill = yellow] (0,0) rectangle (1.5,1);
\path [fill = yellow] (2,0) rectangle (3.5,1);
\end{tikzpicture}
```

Mix `--` and `to` to connect arcs and straight lines.

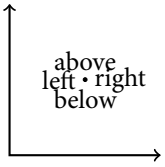
```
\begin{tikzpicture}
\draw [ultra thick] (0,0) to [out = 87, in = 135] (1,1) -- (0.85,
    0.15) -- (0,0);
\draw [ultra thick, fill = purple] (2,0) to [out = 87, in = 135]
    (3,1) -- (2.85, 0.15) -- (2,0);
\path [fill = purple] (4,0) to [out = 87, in = 135] (5,1) -- (4.85,
     0.15) -- (4,0);
\end{tikzpicture}
```

10 LABELS IN PICTURES



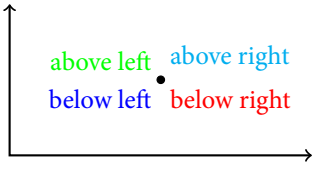

```
\begin{tikzpicture}
\draw [help lines] (0,0) grid (2,2);
\draw [thick, <->] (0,2) -- (0,0) -- (2,0);
\node at (1,1) {yes};
\end{tikzpicture}
```

"yes" is positioned such that the baseline of the text is centered on `(1,1)`. For positioning labels relative to a point,




```
\begin{tikzpicture}
\draw [thick, <->] (0,2) -- (0,0) -- (2,0);
\draw [fill] (1,1) circle [radius = 0.025];
\node [below] at (1,1) {below};
\node [above] at (1,1) {above};
\node [left] at (1,1) {left};
\node [right] at (1,1) {right};
\end{tikzpicture}
```

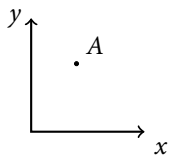
Compound positioning is also possible,




```
\begin{tikzpicture}[scale = 2.0]
```

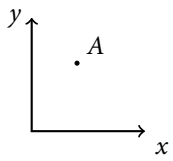
```
\draw [thick, <->] (0,2) -- (0,0) --(2,0);
\draw [fill] (1,1) circle [radius = 0.025];
\node [below right, red] at (1,1) {below right};
\node [above left, green] at (1,1) {above left};
\node [below left, blue] at (1,1) {below left};
\node [above right, cyan] at (1,1) {above right};
\end{tikzpicture}
```

Labeling axes and points is also easy.



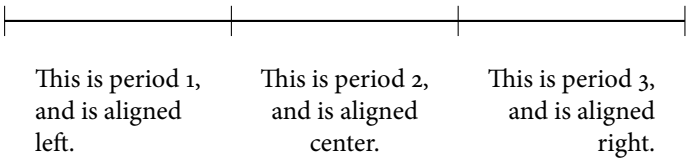

```
\begin{tikzpicture}[scale = 1.5]
\draw [thick, <->] (0,1) -- (0,0) --(1,0);
\node [below right] at (1,0) {$x$};
\node [left] at (0,1) {$y$};
\draw [fill] (0.4, 0.6) circle [radius = 0.5 pt];
\node [above right] at (0.4, 0.6) {$A$};
\end{tikzpicture}
```

Alternatively, nodes can be mixed in the middle of paths.




```
\begin{tikzpicture}[scale = 1.5]
\draw [thick, <->] (0,1) node [left] {$y$} -- (0,0)
        -- (1,0) node [below right] {$x$};
\draw [fill] (0.4, 0.6) circle [radius = 0.5 pt]
        node [above right] (0.4, 0.6) {$A$};
\end{tikzpicture}
```

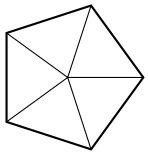
Multiple lines can be added to nodes with \\, but alignment of the node text must be explicitly specified.




```
\begin{tikzpicture}
\draw [thick] (0,0) to (9,0);
\draw (0, -0.2) to (0, 0.2);
\draw (3, -0.2) to (3, 0.2);
\draw (6, -0.2) to (6, 0.2);
\draw (9, -0.2) to (9, 0.2);
\node[align = left, below] at (1.5, -0.5)
        {This is period 1,\\and is aligned\\left.};
\node[align = center, below] at (4.5, -0.5)
        {This is period 2,\\and is aligned\\center.};
\node[align = right, below] at (7.5, -0.5)
        {This is period 3,\\and is aligned\\right.};
\end{tikzpicture}
```

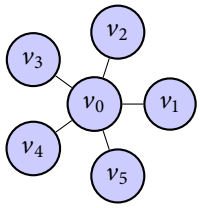
11 NAMING COORDINATES

Coordinates can be named with the `\path...\coordinate` command. Non-contiguous line segments can be drawn by omitting the `--` command.



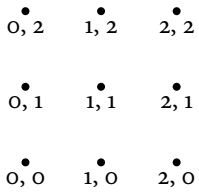
```
\begin{tikzpicture}
\path (0,0) coordinate (origin);
\path (0*72:1 cm) coordinate (P0);
\path (1*72:1 cm) coordinate (P1);
\path (2*72:1 cm) coordinate (P2);
\path (3*72:1 cm) coordinate (P3);
\path (4*72:1 cm) coordinate (P4);

\draw [thick] (P0) -- (P1) -- (P2) -- (P3) -- (P4) -- cycle;
\draw (origin) -- (P0) (origin) -- (P1) (origin) -- (P2)
        (origin) -- (P3) (origin) -- (P4);
\end{tikzpicture}
```

12 MORE NODES

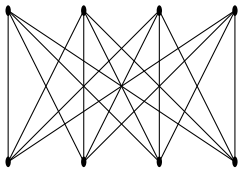



```
\begin{tikzpicture}\tikzset{
every node/.style = {circle, thick, draw, text centered,
                                        fill = blue!20}}

\path (0:0 cm) node (v0) {$v_0$};
\path (0*72:1 cm) node (v1) {$v_1$};
\path (1*72:1 cm) node (v2) {$v_2$};
\path (2*72:1 cm) node (v3) {$v_3$};
\path (3*72:1 cm) node (v4) {$v_4$};
\path (4*72:1 cm) node (v5) {$v_5$};

\draw (v0) -- (v1) (v0) -- (v2) (v0) -- (v3)
        (v0) -- (v4) (v0) -- (v5);
\end{tikzpicture}
```

13 LOOPING

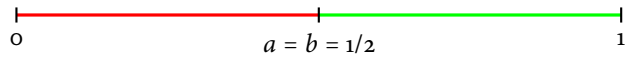



```
\begin{tikzpicture}
\foreach \j in {0,...,2}
\foreach \i in {0,...,2}{
        \path (\i,\j) coordinate (x\i\j);
        \fill (x\i\j) circle (1.5pt) node [below] {\i, \j};
}
\end{tikzpicture}
```



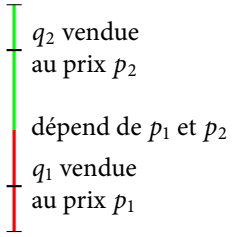
```
\begin{tikzpicture}[yscale=2]
\foreach \i / \j in {{1/1}, {2/2}, {3/3}, {4/4}}{
        \path (\i,0) coordinate (X\i);
        \fill (X\i) circle (1pt);
        \path (\j,1) coordinate (Y\j);
        \fill (Y\j) circle (1pt);
} % Naming coordinates and putting circles
\foreach \i in {1,...,4}
\foreach \j in {1,...,4}
        \draw (X\i) -- (Y\j);
        % Drawing connections
\end{tikzpicture}
```

14.1 *Hotelling*



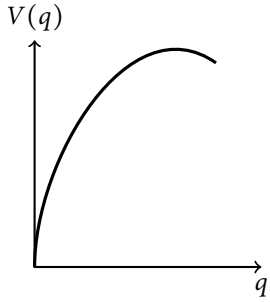

```
\begin{tikzpicture}[xscale = 8]
\draw [red, very thick] (0,0) -- (0.5,0);
\draw [green, very thick] (0.5,0) -- (1,0);
\draw [thick] (0, -0.1) node [below] {0} to (0, 0.1);
\draw [thick] (0.5, -0.1) node [below] {$a=b=$ 1/2} to (0.5, 0.1);
\draw [thick] (1, -0.1) node [below] {1} to (1, 0.1);
\end{tikzpicture}
```

14.2 *Vertical differentiation*



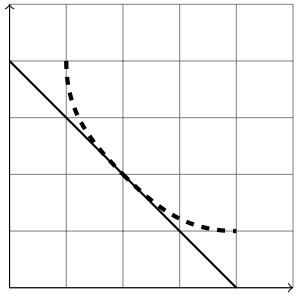

```
\begin{tikzpicture}[yscale=3]
\draw[red, very thick] (0,0) to (0, 0.45);
\draw[green, very thick] (0,0.45) to (0, 1);
\draw (-0.1, 0) to (0.1, 0);
\draw[thick] (-0.1, 0.2) to (0.1, 0.2)
        node [align = left, right]
        {$q_1$ vendue\\au prix $p_1$};
\draw[thick] (-0.1, 0.8) to (0.1, 0.8)
        node [align = left, right]
        {$q_2$ vendue\\au prix $p_2$};
\draw (-0.1, 1) to (0.1, 1);
\node [right] at (0.1, 0.45) {d\'epend de $p_1$ et $p_2$};
\end{tikzpicture}
```

14.3 *A curve*



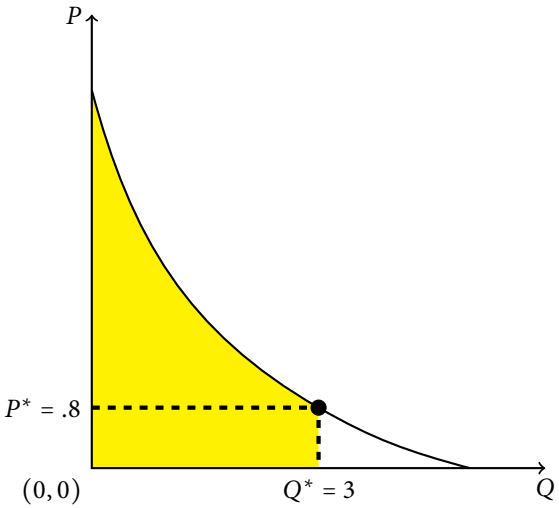

```
\begin{tikzpicture}[scale = 3]
\draw [thick, <->] (0,1) node [above] {$V(q)$}
        -- (0,0) -- (1,0) node [below] {$q$};
\draw [very thick] (0,0) to
        [out = 90, in = 145] (0.8, 0.9);
\end{tikzpicture}
```

14.4 *Tangency*



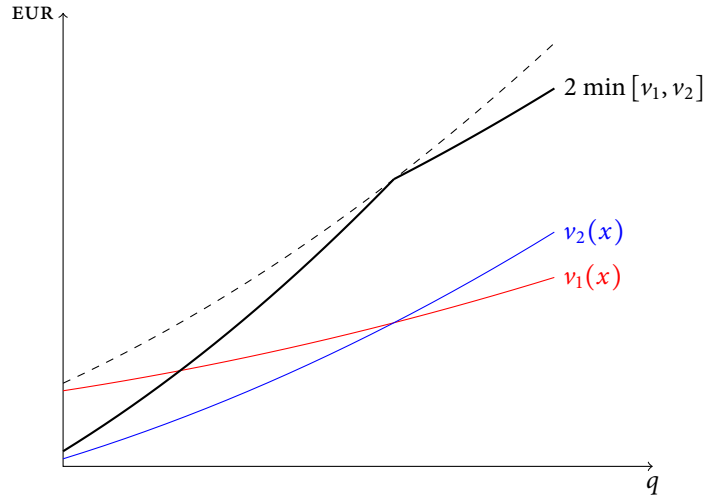
```
\begin{tikzpicture}
\draw [help lines] (0,0) grid (5,5);
\draw [black, <->] (0,5) -- (0,0) -- (5,0);
\draw [thick] (0,4) to (4,0);
\draw [dashed, ultra thick] (1, 4) to
        [out = -90, in = 135] (2,2);
\draw [dashed, ultra thick] (2,2) to
        [out = -45, in = 180] (4, 1);
\end{tikzpicture}
```

14.5 *Consumer surplus*



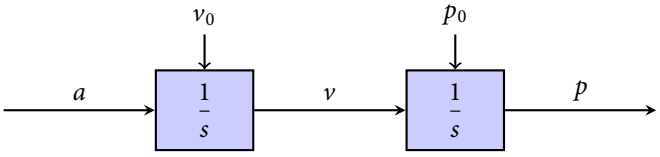

```
\begin{tikzpicture}
\path [fill = yellow] (0,0) to (0,5)
        to [out = -75, in = 150] (3,0.8) -- (3,0) -- (0,0);
\draw [thick, <->] (0,6) node [left] {$P$}
        -- (0,0) node [below left] {$(0,0)$}
        -- (6,0) node [below] {$Q$};
\draw [thick] (0,5) to [out = -75, in = 150] (3,0.8)
        to [out = -30, in = 165] (5,0);
\draw [ultra thick, dashed] (0, 0.8) node [left] {$P^* = .8$}
        -- (3, 0.8) -- (3,0) node [below] {$Q^* = 3$};
\draw [fill] (3, 0.8) circle [radius = 0.1];
\end{tikzpicture}
```

14.6 *Lots of curves*




```
\begin{tikzpicture}[domain = 0:0.5, xscale = 13, yscale = 4]
\draw [<->] (0, 2) node [left] {\textsc{eur}}
        -- (0,0) -- (0.7, 0) node [below] {$q$};
\draw [red] plot (\x, {0.25+\x/2 + \x*\x/2}) node [right] {$v_1(x)
    $};
\draw [blue] plot (\x, {0.025 + \x + \x*\x}) node [right] {$v_2(x)
    $};
\draw [thin, dashed] plot (\x, {0.275 + 1.5*\x + 1.5*\x *\x});
\draw [thick, domain = 0:0.33666] plot (\x, {0.05+2*\x + 2*\x*\x});
\draw [thick, domain = 0.33666:0.5] plot (\x, 0.5 + \x + \x*\x)
        node [right] {$2 \text{ min}\left[ v_1, v_2 \right] $};
\end{tikzpicture}
```

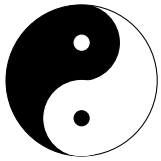
14.7 *Simple block diagram*




```
\begin{tikzpicture}[node distance = 2cm, auto]\tikzset{
block/.style = {rectangle, thick, draw,
                text width = 3 em, text centered,
                minimum height = 3 em, fill = blue!20},
line/.style = {draw, ->, thick, >=stealth},
init/.style = {pin edge = {to-, thick, black}}}

\node [block, pin = {[init] above:$v_0$}]
        (a) {$\dfrac{1}{s}$};
\node [left = of a, node distance = 2cm, coordinate] (begin) {};
\node [block, pin = {[init] above:$p_0$}, right = of a]
        (c) {$\dfrac{1}{s}$};
\node [right = of c, node distance = 2cm, coordinate] (end) {};
```

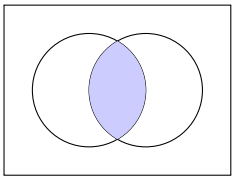
```
\path [line] (begin) -- node {$a$} (a);
\path [line] (a) -- node {$v$} (c);
\path [line] (c) -- node {$p$} (end);
\end{tikzpicture}
```

14.8 *Yin-yang*



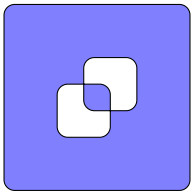
```
\begin{tikzpicture}[scale = 1]
\draw (0,0) circle [radius = 1];
\clip (0,0) circle [radius = 1];
\draw [fill] (-1, -1) rectangle (0,1);

\draw [fill] (0, 0.5) circle [radius = 0.5];
\draw [fill, white] (0, -0.5) circle [radius = 0.5];
\draw [fill] (0, -0.5) circle [radius = 0.1];
\draw [fill, white] (0,0.5) circle [radius = 0.1];
\end{tikzpicture}
```

14.9 *Set intersection*



```
\begin{tikzpicture}[scale = 0.75]
\draw (-2, 1.5) rectangle (2, -1.5);
\draw (-0.5, 0) circle [radius = 1 cm];
\draw (0.5, 0) circle [radius = 1 cm];
\clip (-0.5, 0) circle [radius = 1 cm];
\clip (0.5, 0) circle [radius = 1 cm];
\draw [fill, blue!20] (-2, 1.5) rectangle (2, -1.5);
\end{tikzpicture}
```

14.10 *Even odd rule*



```
\begin{tikzpicture}[even odd rule, rounded corners,
                            x = 1em, y = 1em, scale = 2]
\filldraw[fill = blue!50] (0,0) rectangle (1,1)
[xshift = 0.5em, yshift = 0.5em] (0,0) rectangle (1,1)
(-1.5,-1.5) rectangle (2,2);
\end{tikzpicture}
```